An Improved Particle Swarm Optimization for Proficient Solving of Unit Commitment Problem

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***Abstract*—This paper presents a new approach to solving the short-term unit commitment problem using an improved Particle Swarm Optimization (IPSO). The objective of this paper is to find the generation scheduling such that the total operating cost can be minimized, when subjected to a variety of constraints. This also means that it is desirable to find the optimal generating unit commitment in the power system for the next H hours. PSO, which happens to be a Global Optimization technique for solving Unit Commitment Problem, operates on a system, which is designed to encode each unit's operating schedule with regard to its minimum up/down time. In this, the unit commitment schedule is coded as a string of symbols. An initial population of parent solutions is generated at random. Here, each schedule is formed by committing all the units according to their initial status ("flat start"). Here the parents are obtained from a pre-defined set of solution's i.e. each and every solution is adjusted to meet the requirements. Then, a random decommitment is carried out with respect to the unit's minimum down times. A thermal Power System in India demonstrates the effectiveness of the proposed approach; extensive studies have also been performed for different power systems consist of 10, 26, 34 generating units. Numerical results are shown comparing the cost solutions and computation time obtained by using the IPSO and other conventional methods like Dynamic Programming (DP), Legrangian Relaxation (LR) in reaching proper unit commitment.**

***Index Terms*—Unit Commitment, Particle Swarm Optimization, Legrangian Relaxation, Dynamic Programming**

I. INTRODUCTION

In power stations, the investment is pretty costlier and the resources in operating them are considerably becoming sparse of which focus turns on to optimizing the operating cost of the power station [1]. The demand for the electricity is varying in a daily and weekly cyclic manner and this creates a problem for the power system in deciding the best way to meet those varying demands [2]. The demand knowledge in the future is the main problem of the planning. With an accurate forecast, the basic operating functions like thermal and hydrothermal UC, economic dispatch, fuel scheduling and unit maintenance can be performed efficiently [3]. The energy production cost varies considerably between all the energy sources available on a power system. Moreover it requires a tool in order to balance the demand and generation and also to dispatch the generation optimally in the most economical way [4].

Power system operators have to face the decision-making problems extensively because of these difficulties. The scheduling of generators in a power system at any given time is one of the decision making problems. Running all the units is not economical for a power system which is required to satisfy the peak load during low load periods [5]. The main objective is to reduce the power generation costs when meeting the hourly forecasted power demands. UCP is the method of finding an optimal turn on and turn off schedule for a group of power generation units for each time window over a given time horizon [10]. The UCP is a vital area of research which concerns more attention from the scientific community because of the fact that even small savings in the operation costs for each hour can lead to the major overall economic savings [6]. In order to decide which of the available power plants should be involved to supply the electricity, the best choice is the UC which is called as Unit Commitment [7]. UCP is an area of production scheduling which is related to decide the ON/OFF status of the generating units during each interval of the scheduling period. This is done in order to meet the system load and reserve requirements and minimum cost which are exposed to many types of equipment, system and environmental constraints [8]. The UC should simultaneously reduce the cost of the system production when it satisfies the load demand, spinning reverse, ramp constraints and the operational constraints of the individual unit [9].

Some of the recent research works related to solving the UCP is discussed as follows. A novel approach for solving the short- term commitment problem using the genetic algorithm based tabu search method with cooling and banking constraints was proposed [2]. The main aim of his work is to find the generation scheduling so that the total operating cost can be reduced, when subjected to a variety of constraints. A two- layer approach for solving the UCP in which the first layer utilizes a Genetic Algorithm to decide the on\off status of the units and second layer utilizes an Improved Lambda- Iteration technique to solve the Economic Dispatch Problem was presented [11]. Their approach satisfies all the plant and system constraints. UCP for four-unit Tuncbilek thermal plant which was in

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Kutahya region in Turkey, was solved [3] for an optimum schedule of generating units based on the load data forecasted by using the conventional ANN (ANN) and an improved ANN model with Weighted Frequency Bin Blocks (WFBB). They have used Fuzzy Logic (FL) method for solving the UCP. Three evolutionary computation techniques, namely Steady-State Genetic Algorithms, Evolutionary Strategies and Differential Evolution for the UCP have compared [12]. Their comparison was based on a set of experiments conducted on benchmark datasets as well as on real-world data obtained from the Turkish Interconnected Power System. An algorithm which is used to solve security constrained UCP with both operational and power flow constraints (PFC) have been proposed [9] for planning a secure and economical hourly generation schedule. Their algorithm introduces an efficient unit commitment (UC) approach with PFC which obtains the minimum system operating cost which satisfies both unit and network constraints when contingencies are included.

Alternative strategies with the advantages of Genetic Algorithm for solving the Thermal UCP and in addition to these they have developed [8]. Parallel Structure to handle the infeasibility problem in a structured and improved Genetic Algorithm (GA) which provides an effective search and therefore greater economy. A novel approach for solving the Multi- Area Commitment problem using an evolutionary programming technique has proposed [13]. Their technique was used to improve the speed and reliability of the optimal search process. A dynamic programming algorithm for solving the single-UCP (1-UCP) which efficiently solves the single-unit economic dispatch (ED) problem with ramping constraints and arbitrary convex cost functions have proposed [14]. The analytical and computational necessary & sufficient conditions to determine the feasible unit commitment states with grid security constraints have presented [15]. The optimal scheduling of hydropower plants in a hydrothermal connected system has considered [16]. In their model they have related the amount of generated hydropower to nonlinear traffic levels and also have taken into account the hydraulic losses, turbine- generator efficiencies as well as multiple 0-1 states associated with forbidden operation zones.

From the surveyed research works it can be understood that solving the UCP gains high significance in the domain of power systems. Solving the UCP by a single optimization algorithm is ineffective and time consuming. Hence, we are proposing a UCP solving approach based on improved PSO which provides an effective scheduling with minimum cost. The proposed approach solves the UCP with less time consumption rather than the approaches solely based on a single optimization algorithm.

II. PARTICLE SWARM OPTIMIZATION

PSO first introduced by Eberhart and Kennedy in 1995 which uses the natural animal's behavior like bird flocking, fish schooling, and swarm theory to produce the best of the characters among comprehensive old populations [17-20]. The basic PSO algorithm can be described as follows: Each particle in the swarm represents a possible solution to the existing optimization problem. During PSO iteration, every particle accelerates independently in the direction of its own personal best solution which is found so far, as well as the direction of the global best solution which is discovered so far by the other particles. Therefore, if a particle finds a promising new solution, all other particles will move closer to it, exploring the solution space more thoroughly [22]. Computation in PSO is based on a population (swarm) of processing elements called particles in which each particle represent a candidate solution [18]. The PSO algorithm depends on the social interaction between independent particles, during their search for the optimum solution [19].

PSOs are initialized with a population of random solutions and search for optima by updating generations [21]. All particles have fitness values which are estimated by the fitness function to be optimized, and have velocities which direct the flying of particles [20]. The fitness function is evaluated for each particle in the swarm and is compared to the fitness of the best previous result for that particle and to the fitness of the best particle among all particles in the swarm [24]. The algorithm iterates by updating the velocities and positions of the particles, until the stopping criteria is met [25]. The position (i.e. solution) of every individual particle will be attracted stochastically towards their related best positions (i.e. best solutions) in multidimensional solution space [20]. The PSO algorithm is becoming very popular due to its simplicity of implementation and ability to quickly converge to a reasonably good solution. Nowadays, PSO algorithm is effectively applied in power system optimization, traffic planning, engineering design and optimization, and computer system etc [23].

III. PROBLEM FORMULATION

The main aim is to find the generation scheduling so that the total operating cost can be reduced when it is exposed to a variety of constraints [26]. The overall objective function of the UCP is given below,

$$F_T = \sum_{t=1}^{T} \sum_{i=1}^{N} \left(F_{it}\left(P_{it}\right) U_{it} + S_{it} V_{it} \right) \frac{\text{Rs}}{\text{h}} \qquad (1)$$

Where

U_{it} ~ unit i status at hour t=1(if unit is ON)=0(if unit is OFF)

V_{it} ~ unit i start up / shut down status at hour t =1 if the unit is started at hour t and 0 otherwise.

F_T ~ total operating cost over the schedule horizon (Rs/Hr)

S_{it} ~ start up cost of unit i at hour t (Rs)

For thermal and nuclear units, the most important component of the total operating cost is the power production cost of the committed units. The quadratic form for this is given as

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$$F_{it}\left(P_{it}\right) = A_i P^2{}_{it} + B_i P_{it} + C_i \frac{Rs}{h} \qquad (2)$$

A_i, B_i, C_i ~ the cost function parameters of unit i (Rs./MW^{2}hr, Rs./MWhr, Rs/hr)

$F_{it}(P_{it})$ ~ production cost of unit i at a time t (Rs/hr)

P_{it} ~ output power from unit i at time t (MW)

The startup value depends upon the downtime of the unit. When the unit i is started from the cold state then the downtime of the unit can vary from a maximum value. If the unit i have been turned off recently, then the downtime of the unit varies to a much smaller value. During the downtime periods, the startup cost calculation depends upon the treatment method for the thermal unit. The startup cost S_{it} is a function of the downtime of unit i and it is given as

$$S_{it} = So_i\left[1 - D_i \exp\left(\frac{-Toff_i}{Tdown_i}\right)\right] + E_i Rs \qquad (3)$$

Where

So_i ~ unit i cold start – up cost (Rs)

D_i, E_i ~ start – up cost coefficients for unit i

A. Constraints

Depending on the nature of the power system under study, the UCP is subject to many constraints, the main being the load balance constraints and the spinning reserve constraints. The other constraints include the thermal constraints, fuel constraints, security constraints etc. [26]

B. Load Balance Constraints

The real power generated must be sufficient enough to meet the load demand and must satisfy the following factors given in (4).

$$\sum_{i=1}^{N} P_{it}U_{it} = PD_t \qquad (4)$$

Where

PD_t ~ system peak demand at hour t (MW)

N ~ number of available generating units

U(0,1) ~ the uniform distribution with parameters 0 and 1

UD(a,b) ~ the discrete uniform distribution with parameters a and b

C. Spinning Reserve Constraints

The spinning reserve is the total amount of real power generation available from all synchronized units minus the present load plus the losses. It must be sufficient enough to meet the loss of the most heavily loaded unit in the system. This has to satisfy the equation given in (5).

$$\sum_{i=1}^{N} P\max_i U_{it} >= (PD_t + R_t); 1 \le t \le T \qquad (5)$$

Where

$P\max_i$ ~ Maximum generation limit of unit i

R_t ~ spinning reserve at time t (MW)

T ~ scheduled time horizon (24 hrs.)

D. Thermal Constraints

The temperature and pressure of the thermal units vary very gradually and the units must be synchronized before they are brought online. A time period of even 1 hour is considered as the minimum down time of the units. There are certain factors, which govern the thermal constraints, like minimum up time, minimum down time and crew constraints.

Minimum up time:

If the units have already been shut down, there will be a minimum time before they can be restarted and the constraint is given in (6).

$$Ton_i \ge Tup_i \qquad (6)$$

Where

Ton_i ~ duration for which unit i is continuously ON (Hr)

Tup_i ~ unit i minimum up time (Hr)

Minimum down time:

If all the units are running already, they cannot be shut down simultaneously and the constraint is given in (7).

$$Toff_i \ge Tdown_i \qquad (7)$$

Where

$Tdown_i$ ~ unit i minimum down time (Hr)

$Toff_i$ ~ duration for which unit i is continuously OFF (Hr)

E. Must Run Units

Generally in a power system, some of the units are given a must run status in order to provide voltage support for the network.

F. Ramping Constraints

If the ramping constraints are included, the quality of the solution will be improved but the inclusion of ramp-rate limits can significantly enlarge the state space of production simulation and thus increase its computational requirements. And it results in significantly more states to be evolved and more strategies to be saved. Hence the CPU time will be increased.

When ramp-rate limits are ignored, the number of generators consecutive online/offline hours at hour t, provides adequate state description for making its commitment decision at hour (t+1). When ramp-rate limits are modeled, the state description becomes inadequate. An additional status, generators energy generation capacity at hour t is also required for making its commitment decision at hour (t+1). These additional descriptions add one more dimension to the state space, and thus significantly increase the computational requirements. Therefore, we have not included in this algorithm.

IV. IMPROVED PSO ALGORITHM FOR SOLVING UCP

The proposed IPSO Algorithm is to determine the units and their generation schedule for a particular demand with

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minimum cost. In this manner, with the assistance of PSO we determine the same for different possible demands. The problem is divided into two stages; one is for determining the minimum cost for a particular demand and another is for determining the minimum cost for unit commitment during all the periods. But the demand varies during all the periods. Hence, different possible demands are need to be generated which can be performed by the IPSO algorithm. PSO is used to determine the optimal generation schedule for a particular demand. The steps of the algorithms which is used for our approach is demonstrated in the "Fig. 1".

As depicted in "Fig. 1", for a power demand of P_d, initially, a population of random individuals is taken. The random individuals include random particles and their velocities. Hereby, a logical algorithm is utilized to generate the initial random solutions of particles which can be discussed as follows

1. Generate an arbitrary integer r which satisfies the condition $r \le n$.
2. For the r^{th} unit, generate a random integer indicating the power generated by the unit which should essentially satisfy the condition $P_{g_r}^{(\min)} \le P_{g_r} \le P_{g_r}^{(\max)}$
3. The remaining power to be generated i.e. $P_d - P_{g_r}$ is subjected for the following decision,
$$P_d = \begin{cases} P_d - P_{g_r} & ;\ if\ \ P_d - P_{g_r} < P_{th} \\ \dfrac{P_d - P_{g_r}}{2} & ;\ else \end{cases} \tag{8}$$
4. Allot P_d to the next unit to generate (now, let the next unit as r) whose maximum limit of power generation is greater than the remaining free units. The allotment of P_d to the unit is based on the following condition
$$P_{g_r} = \begin{cases} P_d & ;if\ \ P_{g_r}^{(\min)} \le P_d \le P_{g_r}^{(\max)} \\ P_{g_r}^{(\min)} & ;if\ \ P_d < P_{g_r}^{(\min)} \\ P_{g_r}^{(\max)} & ;if\ \ P_d > P_{g_r}^{(\max)} \end{cases} \tag{9}$$
5. Determine $P_d - P_{g_r}$. If $P_d - P_{g_r} < 0$, go to step 1; If $P_d - P_{g_r} > 0$, go to step 3; If $P_d - P_{g_r} = 0$, then terminate the criteria.

By the above mentioned algorithm, a vector is obtained which represents the amount of power to be generated by each unit. Hence, some different possible vectors are generated by repeating the algorithm and it can be given as

$$P_i = \left\lfloor P_{g_1}^{(i)}, P_{g_2}^{(i)}, \cdots, P_{g_n}^{(i)} \right\rfloor \tag{10}$$

Equation (13) represents the initial particles that are satisfying the constraints given in equation (4) and (5) are generated as random initial solutions for the PSO algorithm. In parallel, random velocities are also generated for the corresponding particles as follows

$$v_i = \left\lfloor v_1^{(i)}, v_2^{(i)}, \cdots, v_n^{(i)} \right\rfloor \tag{11}$$

In equation (14), the velocities for each particle element are randomly generated within the maximum and minimum limit and so the each element of the velocity vector v_i satisfies $v_{\min} \le v_i\ (j) \le v_{\max}$. After determining the initial particles and their corresponding velocities, the particles are evaluated by the evaluation function which is given by

$$\min \sum_{i=1}^{n} (F_{it}(P_{it})U_{it} + S_{it}V_{it}) \frac{R_s}{h} \tag{12}$$

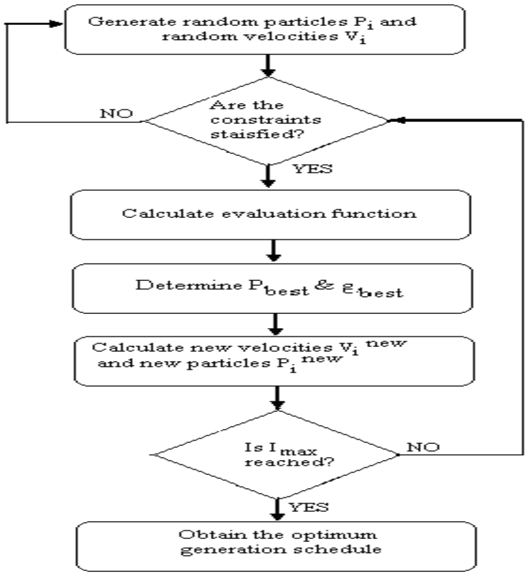
Generate random particles P_i and random velocities V_i
Are the constraints staisfied?
NO
YES
Calculate evaluation function
Determine P_{best} & g_{best}
Calculate new velocities V_i^{new} and new particles P_i^{new}
Is I_{max} reached?
NO
YES
Obtain the optimum generation schedule

Figure 1. Steps involved in PSO to determine the optimal generation schedule

Based on the evaluation function given in equation (15), p_{best} and g_{best} for the initial particles are determined. Then new velocities are determined as

$$v_i^{new}(j) = w * v_i^{cnt}(j) + c_1 * a_1 * [p_{best_i}(j) - P_i^{cnt}(j)] + c_2 * a_2 * [g_{best}(j) - P_i^{cnt}(j)] \tag{13}$$

where, $1 \le i \le l$, $1 \le j \le n$, $v_i^{cnt}(j)$ stands for current velocity of the particle, $v_i^{new}(j)$ stands for new velocity of a particular parameter of a particle, a_1 and a_2 are arbitrary numbers in the interval $[0,1]$, c_1 and c_2 are acceleration constants (often chosen as 2.0) and w is the inertia weight that is given as

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$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{I_{\max}} \times I \qquad (14)$$

where, $w_{\max}$ and $w_{\min}$ are the maximum and minimum inertia weight factors respectively which are chosen randomly in the interval $[0,1]$, I is the current number of iteration and $I_{\max}$ is the maximum number of iterations. The velocity of such newly attained particle should be within the limits. Before proceeding further, this would be checked and corrected.

$$v_i^{new}(j) = \begin{cases} v_{\max}(j) & ; \ v_i^{new}(j) > v_{\max}(j) \\ v_{\min}(j) & ; \ v_i^{new}(j) < v_{\min}(j) \end{cases} \qquad (15)$$

Depend upon the newly obtained velocity vector, the particles are updated and obtained as new particles as follows

$$P_i^{new}(j) = P_i^{new}(j) + v_i^{new}(j) \qquad (16)$$

Then the parameter of each particle is checked whether it is ahead the lower and upper bound limits. The minimum and maximum generation limit of each unit is referred by the lower and upper bound values respectively. If the new particle infringes the minimum and maximum generation limit, then a decision making process is performed as follows

$$P_i^{new}(j) = \begin{cases} P_{g_i}^{(\max)} & ; \ if \quad P_{g_i}^{new}(j) > P_{g_i}^{(\max)} \\ P_{g_i}^{(\min)} & ; \ if \quad P_{g_i}^{new}(j) < P_{g_i}^{(\min)} \end{cases} \qquad (17)$$

The newly obtained particles are evaluated as mentioned earlier and so p_{best} for the new particles are determined. With the concern of p_{best} and the g_{best}, new g_{best} is determined. Again by generating new particles, the same process is repeated until the process reaches the maximum iteration $I_{\max}$. Once the iteration reaches the $I_{\max}$, the process is terminated and so that a generation schedule of all the units with minimum cost is obtained which will meet the demand at the particular period. In the similar fashion, the optimum generating schedule for all the possible demand set is determined. So, a complete training set which includes the various possible demands and the corresponding optimum generation schedule is generated.

V. RESULTS AND DISCUSSION

The proposed intelligence technique for UCP which is based on the IPSO has been implemented in the working platform of MATLAB (version 7.8). We have considered an Indian thermal power system with seven unit's utility system for a time span of 24 hours for evaluating the performance of the proposed technique. The operation data for the system is given in the Table I. The daily load data of 10, 26, 34 unit systems are shown in Table II.

Table I
Operation Data Of Seven Units Utility System

Unit	Running Cost			Start-up cost			P_{min} (MW)	P_{max} (MW)
	A_i (Rs/MWh^2)	B_i (Rs/MWh)	C_i (Rs)	So_i (Rs)	D_i (Rs)	E_i (Rs)		
1	0.255	70	750	4250	29.5	10	15	60
2	0.198	75	1250	5050	29.5	10	20	80
3	0.198	70	2000	5700	28.5	10	30	100
4	0.191	70	1600	4700	32.5	9	25	120
5	0.106	75	1450	5650	32	9	50	150
6	0.0675	65	4950	14100	37.5	4.5	50	150
7	0.074	60	4100	11350	32	5.5	75	200

Table II
Daily Generation of 10,26,34 Unit System

Hour	Load		
	10 Unit	26 Unit	34 Unit
1	103	1820	1025
2	100	1800	1000
3	90	1720	900
4	85	1700	850
5	103	1750	1025
6	140	1910	1400
7	197	2050	1970
8	240	2400	2400
9	285	2600	2850
10	315	2600	3150
11	330	2620	3300
12	340	2580	3400
13	328	2590	3275
14	295	2570	2950
15	270	2500	2700
16	255	2350	2550
17	272	2390	2725
18	320	2480	3200
19	330	2580	3300
20	290	2620	2900
21	213	2600	2125
22	165	2480	1650
23	130	2150	1300
24	115	1900	1150

The simulated demand set, corresponding generation schedule, the minimum operating cost and the computational time for the utility system is given in the Table III. The status of unit i at time t and the start-up / shut - down status obtained are the necessary solutions and are obtained for DP, LR, PSO, IPSO methods for utility system.

Table III
Optimal Generation Schedule For Utility System Satisfying 24 Hour Demand Along With Its Total Operating Cost

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total Operating Cost (p.u)
Power Demand (MW)	400	410	420	410	430	420	430	440	430	440	450	480	490	480	500	490	500	460	470	440	450	420	440	420	
Unit																									
1	84.5	94.0	89.5	81.5	90.0	90.5	90.0	100	90.0	100	110	48.5	94.5	41.5	101.75	52.5	74.75	110	130	100	110	89.0	113	91.5	0.9763
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	144.5	150	150	128.5	150	139.5	150	150	150	150	150	111.5	150	150	150	150	150	150	150	150	150	150	137	138.5	
6	0	0	0	0	0	0	0	0	0	0	0	150	115.5	118.5	117.25	117.5	108.25	0	0	0	0	0	0	0	
7	171	144	180.5	200	190	190	190	190	190	190	190	170	128	170	131	170	147	200	190	190	190	181	190	190	

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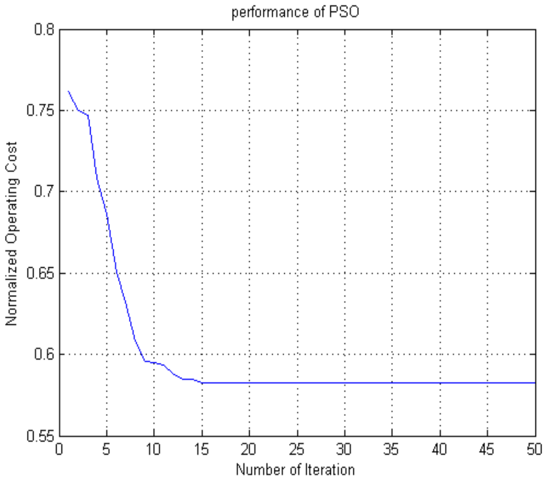

Figure 3. The normalized cost for an optimal generation schedule versus the number of iterations of the PSO operation

The comparison of the total costs and Central Processing unit (CPU) time is shown in Table IV for utility system, 10, 26, and 34 generating unit power systems. The demand for 24 hour time horizon is just simulated and it is not the actual demand which is practically satisfying by the units. An optimal generation schedule for each period and the total operating cost for the whole 24 periods are obtained. The IPSO algorithm contributes in determining the optimal generation schedule for a particular demand. The performance of PSO for a particular demand is depicted in the “Fig. 3”.

Table IV
Comparisons of cost and CPU time for Utility & IEEE systems

System	Methods	Total Cost (p.u)	CPU Time (Sec)
7 – Unit Utility System	DP	1.00000	605
	LR	0.96481	578
	PSO	0.92690	519
	IPSO	0.92420	510
10 – Unit IEEE System	DP	1.00000	325
	LR	0.94123	279
	PSO	0.90905	218
	IPSO	0.90710	211
26 – Unit IEEE System	DP	1.00000	509
	LR	0.95968	495
	PSO	0.91273	440
	IPSO	0.90802	431
34 – Unit IEEE System	DP	1.00000	1452
	LR	0.99910	1368
	PSO	0.95790	1320
	IPSO	0.95185	1307

Given a demand, the PSO generates an optimal unit commitment with minimum cost. In Figure 3, the improvement of PSO is illustrated in terms of offering the commitment of units with minimum cost. The affixed graph is obtained for solving the power demand of 400 MW by the seven unit’s utility system. In every number of iteration, the cost of the schedule offering by the IPSO gets reduced. After a certain number of iterations, the cost remains constant for all the remaining iterations, which means that there no more generation schedule is available with cost which lesser than the previous cost. For the evaluation of performance, we have solved the UCP by IPSO only and thus we have compared the total production cost and computational time taken by the proposed approach and by the PSO to solve the problem and found that it was reduced for the IPSO method for all the systems.

CONCLUSION

The proposed approach IPSO has performed well in solving the UCP by recognizing the optimal generation schedule. The approach has been tested for the seven unit’s utility system with the consideration of load balance and spinning reserve constraints, which are the most significant constraints. Prior to test the system, we have trained the network by different possible combinations of the demand set and its corresponding optimal schedule using the BP algorithm.

For the test demand set which consists of demand for 24 periods, the hybrid approach effectively yields optimal generation schedule for the periods. In comparison with the results produced by the referenced techniques (DP, LR, PSO), the IPSO method obviously displays a satisfactory performance. There is no obvious limitation on the size of the problem that must be addressed, for its data structure is such that the search space is reduced to a minimum; No relaxation of constraints is required; instead, populations of feasible solutions are produced at each generation and throughout the process.

REFERENCES

[1] S Senthil Kumar and V Palanisamy, "A Hybrid Fuzzy Dynamic Programming Approach to Unit Commitment", *Journal of the Institution of Engineers (India) Electrical Engineering Division*, Vol 88, Issue 4, 2008.

[2] Christober C. Asir Rajan, "Genetic Algorithm Based Tabu Search Method for Solving Unit Commitment Problem with Cooling — Banking Constraint", *Journal of Electrical Engineering*, Vol. 60, Issue. 2, pp: 69–78, 2009.

[3] U.BasaranFilik and M.Kurban, "Fuzzy Logic Unit Commitment based on Load Forecasting using ANN and Hybrid Method", *International Journal of Power, Energy and Artificial Intelligence*, Vol. 2, No.1, pp: 78- 83, March 2009.

[4] Jorge Pereira, Ana Vienna, Bogdan G. Lucus and Manuel Matos, "Constrained Unit Commitment and Dispatch Optimization", *19th Mini-Euro Conference on Operation Research Models and Methods in the Energy Sector, Coimbra, Portugal*, 2006.

[5] R. Nayak and J.D. Sharma, "A Hybrid Neural Network and Simulated Annealing Approach to the Unit Commitment Problem", *Computers and Electrical Engineering*, Vol 26, Issue 6, pp: 461-477, 2000.

[6] Ali Keleş, A. Şima Etaner-Uyar and Belgin Türkay, "A Differential Evolution Approach for the Unit Commitment Problem", *In ELECO 2007: 5th International Conference on Electrical and Electronics Engineering*, pp. 132-136, 2007.

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DOI: 01.IJEPE.01.03.551

[7] Kris R. Voorspools and William D. D'haeseleer, "Long Term Unit Commitment Optimization for Large Power Systems; Unit Decommitment versus Advanced Priority Listing", *Applied Energy*, Vol 76, Issue 1-3, pp: 157-167, 2003.

[8] Kaveh Abookazemi, Mohd Wazir Mustafa and Hussein Ahmad, "Structured Genetic Algorithm Technique for Unit Commitment Problem", *International Journal of Recent Trends in Engineering,* Vol 1, Issue 3, May 2009.

[9] S. Prabhakar karthikeyan, K.Palanisamy, I. Jacob Raglend and D. P. Kothari, "Security Constrained UCP with Operational and Power Flow Constraints", *International Journal of Recent Trends in Engineering,* Vol 1, Issue. 3, May 2009.

[10] Ali Keles, "Binary Differential Evolution for the Unit Commitment Problem", *Proceedings of the 2007 GECCO conference companion on Genetic and evolutionary computation*, pp: 2765-2768, 2007.

[11] V. Senthil Kumar and M.R. Mohan, "Genetic Algorithm with Improved Lambda- Iteration Technique to solve the Unit Commitment Problem", in proc. of *Intl. Journal on Electrical and Power Engineering*, Vol. 2, Issue. 2, pp: 85-91, 2008.

[12] A. Sima Uyar and Belgin Turkay, "Evolutionary Algorithms for the Unit Commitment Problem", in proc. of *Turkish Journal on Electrical Engineering*, vol. 16, no. 3, pp: 239-255, 2008.

[13] S.Chitra Selvi, R.P.Kumudini Devi and C.Christober Asir Rajan, "Hybrid Evolutionary Programming Approach to Multi-Area Unit Commitment with Import and Export Constraints", in proc. of *International Journal on Recent Trends in Engineering*, vol. 1, no. 3, May 2009.

[14] Antonio Frangioni and Claudio Gentile, "Solving Nonlinear Single-Unit Commitment Problems with Ramping Constraints", *Operations Research*, vol. 54, no. 4, pp: 767-775, July- August 2006, Doi: 10.1287/opre.1060.0309.

[15] Xiaohong Guan, Sangang Guo, and Qiaozhu Zha, "The Conditions for Obtaining Feasible Solutions to Security-Constrained Unit Commitment Problems", *IEEE Transactions on Power Systems, USA*, Vol. 20, no.4, November 2005.

[16] Erlon C. Finardi, Edson L. Da Silva And Claudia Sagastizábal, "Solving the unit commitment problem of hydropower plants via Lagrangian Relaxation and Sequential Quadratic Programming", *Computational and Applied Mathematics*, vol. 24, no. 3, pp: 317- 341, 2005.

[17] Ling-Feng Hsieh, Chao-Jung Huang And Chien-Lin Huang, "Applying Particle Swarm Optimization To Schedule Order Picking Routes In A Distribution Center," *Asian Journal Of Management And Humanity Sciences*, Vol. 1, No. 4, Pp. 558-576, 2007.

[18] Rabab M. Ramadan and Rehab F. Abdel-Kader, "Face Recognition Using Particle Swarm Optimization-Based Selected Features," *International Journal of Signal Processing, Image Processing and Pattern Recognition*, Vol. 2, No. 2, 2009.

[19] W. T. Li, X. W. Shi and Y. Q. Hei, "An Improved Particle Swarm Optimization Algorithm For Pattern Synthesis Of Phased Arrays," *Progress In Electromagnetic Research*, pp. 319–332, 2008.

[20] Ching-Yi Chen, Hsuan-Ming Feng and Fun Ye, "Hybrid Recursive Particle Swarm Optimization Learning Algorithm In The Design Of Radial Basis Function Networks," *Journal Of Marine Science And Technology*, Vol. 15, No. 1, pp. 31-40, 2007.

[21] D. Nagesh Kumar and M. Janga Reddy, "Multipurpose Reservoir Operation Using Particle Swarm Optimization," *Journal of Water Resources Planning and Management*, Vol. 133, No. 3, pp. 192-201, 2007.

[22] Faten Ben Arfia, Mohamed Ben Messaoud, Mohamed Abid, "Nonlinear adaptive filters based on Particle Swarm Optimization," *Leonardo Journal of Sciences*, No. 14, pp. 244-251, 2009.

[23] Qi Kang, Lei Wang and Qi-di Wu, "Research on Fuzzy Adaptive Optimization Strategy of Particle Swarm Algorithm," *International Journal of Information Technology*, Vol.12, No.3, pp.65-77, 2006.

[24] Rehab F. Abdel-Kader, "Particle Swarm Optimization for Constrained Instruction Scheduling," *VLSI Design*, Vol. 2008, No. 4, pp. 1-7, 2009.

[25] R.Karthi, S.Arumugam and K. Rameshkumar, "Comparative evaluation of Particle Swarm Optimization Algorithms for Data Clustering using real world data sets," *International Journal of Computer Science and Network Security,* VOL.8, No.1, 2008.

[26] A. J. Wood and B. F. Woollenberg, "*Power Generation and Control", II edition*, New York: Wiley, 1996.

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